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INFORMATION CIRCULAR

METHOD AND COST OF MINING THE PITTSBURGH, OR NO. 8, COAL BED IN FOUR EASTERN OHIO MINES

BY

J. W. PAUL AND H. TOMLINSON

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METHOD AND COST OF MINING THE PITTSBURGH, OR NO. 8, COAL BED IN FOUR EASTERN OHIO MINES[1]

By J. W. Paul[2] and H. Tomlinson[3]

This circular is one of a series of papers[4] on coal-mining methods and costs which are being prepared through the sponsorship of the U. S. Bureau of Mines for the purpose of presenting information on present mining methods and certain features which govern costs, safety, and conservation.

The methods employed are influenced by natural local conditions with respect to the thickness, character, and dip of the coal bed, the nature of the roof and thickness of the overbearing strata, and the means employed for roof support and its control.

Mining costs are governed by the relative efficiency in applying the methods employed underground, as well as by the selection of the method best adapted to the physical conditions encountered, and also by practices that have been introduced through the influence of labor agreements.

This paper presents a detailed description of the methods employed and the results obtained in the operation of four mines developed in the Pittsburgh, or No. 8, coal bed in eastern Ohio, whose product is sold in the open market for domestic and steam fuel.

ACKNOWLEDGMENT

Through the courtesy of the general manager and the cooperation of the operating staff of the mines under discussion, the details given herein have been made possible. This paper is printed with the approval of the executive official, who has checked the accuracy of the methods and data given.

1 - The Bureau of Mines will welcome reprinting of this paper, provided the following footnote acknowledgment is used: "Reprinted from U. S. Bureau of Mines Information Circular 6208."

2 - Senior mining engineer, U. S. Bureau of Mines, Pittsburgh Experiment Station, Pittsburgh, Pa.

3 - Associate mining engineer, Pittsburgh Experiment Station.

4 - See circulars 6113, 6119, 6121, 6138.

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HISTORY

These four mines have been operating since 1918, but have not at all times been part of the present company or under the same management. However, since they have been operated by the present companies 6,222,344 tons of coal has been produced up to and including March 31, 1929.

The Pittsburgh or No. 8 bed, outcropping as it does in so many places, must have been known to the residents of eastern Ohio from the time of its settlement, but the coal was first used for domestic fuel about 1825. About 1835 it was first shipped by river from a mine on the south bank of McMahon's Creek at Bellaire. At approximately the same time other mines were opened at the north end of Bellaire and at West Wheeling.

Between 1835 and 1840 a mine was opened just south of Bellaire on land now within the corporation limits, and a few years later a mine was opened at Wegee, 6 miles farther south.

About 1845 the river shipment of coal became active, and the fuel was sent as far south as New Orleans. At first the coal was loaded on flats and allowed to drift, but after 1850 the fuel was shipped principally in barges. Much coal was used on the boats for making steam and Bellaire became a regular stopping place for loading.

The first railroad mine is said to have been opened in 1858 in a locality about 1 mile west of Bellaire. This mine supplied coal for locomotives and for shipment. About 10 years later another railroad mine was opened at Franklin Station, 8 miles west of Bellaire. Since that year other mines have been opened from time to time, but it was not until about the year 1900 that the Pittsburgh or No. 8 bed became fully developed.

GEOLOGY AND TOPOGRAPHY

Figure 1 is a typical section of the geological measures. The rocks are embraced in the Monongahela group of the Carboniferous age and are composed of shales, sandstones, limestones, and several coal beds, the most important of which is the Pittsburgh or No. 8 bed, which is the lowest member of the group; two other coal beds are the Pomeroy and the Meigs. The Pomeroy bed is 15 to 24 inches thick and lies 22 to 55 feet above the Pittsburgh bed. The Meigs bed is 15 to 48 inches thick and lies 66 to 100 feet above the Pittsburgh bed. Between the Pittsburgh and the Pomeroy coal beds is a bed of limestone 14 to 20 feet thick which lies 5 to 9 feet above the Pittsburgh or No. 8 coal. Pillars are not recovered in this district and it is claimed to be due to the difficulty encountered in controlling the limestone although there is no case in evidence of wide pillars having been tried. The elevation at these mines varies between 900 and 1,600 feet A.T.

The topography of the district consists of a series of rolling hills and wide valleys, offering easy access to the coal bed by drifts, shallow shafts, and short slopes.

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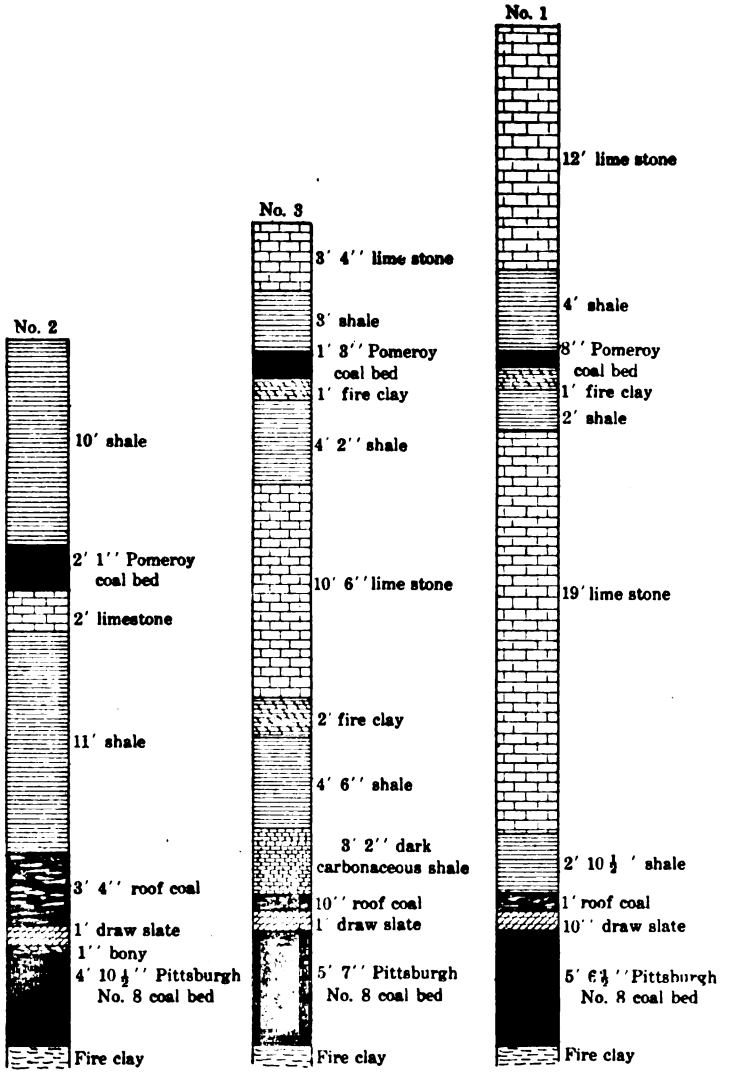

Figure 1. — Typical geological section of the Eastern Ohio coal field. No. 2, from 4 miles northwest of Dillonvale; No. 3, from Section 10, Wyne Township, Belmont County; No. 1, from Pease Township, Belmont County

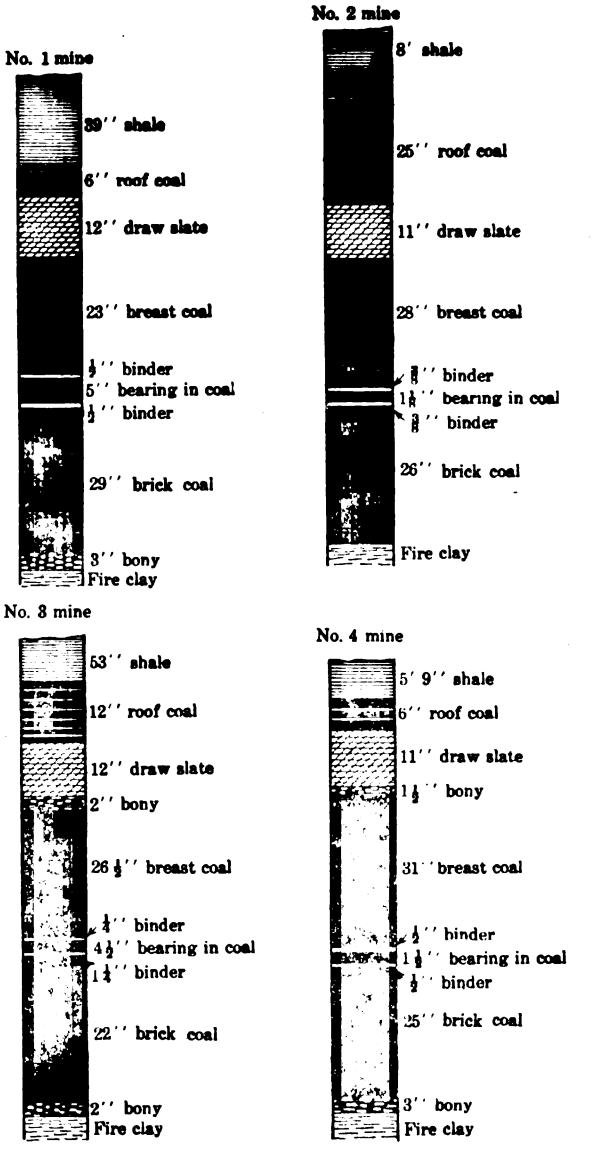

Figure 2. — Typical cross sections of the coal bed and immediate roof at the various mines

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CHARACTER OF COAL BED AND OVERBURDEN

Figure 2 shows detailed sections of the coal bed worked at the four mines to be described. It averages about 60 inches in thickness throughout the district and is made up of three distinct benches of coal. The brick coal varies from 24 to 29 inches in thickness, and sometimes a shale parting is present anywhere from 2 to 15 inches from the bottom. As a rule, coal below this parting is termed the bottom coal and the parting is termed the brick coal. However, this parting is not always present; the brick coal is always bright and blocky.

The bearing-in bench varies from 1 to 5-1/4 inches in thickness and always has a shale binder of 1/4 to 1-1/4 inches in thickness above and below; it is friable and slacks easily. This bench is one of the characteristics of the Pittsburgh coal, and is present wherever it is found.

The breast coal varies from 22 to 32 inches in thickness, and is of the best quality of the three benches. It is bright and breaks in cubical blocks.

Another distinguishing feature of this coal is its pronounced face slips which run about N. 75° W. The butt slips run at an angle of 90° with the face slips and are not so pronounced.

Immediate Roof.- Immediately above the coal bed a band of bony one-half to 2 inches thick is often found; overlying this is draw slate 10 to 12 inches thick. Occasionally, in small areas this draw slate will disappear and a roof termed "slick top" will be found.

Above the draw slate is a roof varying from 6 to 18 inches. It has a distinct parting 2 to 3 inches above the draw slate, which forms the roof over the various mines wherever it can be held in place.

Above the roof coal is a treacherous soft shale 3 to 9 feet thick, which presents a difficult and expensive roof problem on account of its easy disintegration whenever it is exposed to the air.

Floor.- Below the coal bed there is sometimes a band of bony 2 to 3 inches thick, or of fire clay 1 to 6 inches thick, below which is several feet of limestone. The floor is hard and rarely shows any signs of heaving.

Cover.- The cover over the coal bed varies from a few feet at the outcrop to about 200 feet under the hills, with an average of approximately 120 feet over all the mines.

Faults.- There are no displacement faults in the coal. Horsebacks and clay veins are sometimes encountered, but they present no difficult mining problems. Rolls are encountered and the grade on the haulageways for short distances will sometimes be about 4 per cent then gradually return to normal, which is approximately 1-1/2 per cent to the southwest.

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Water.- The mines may be termed damp, a small amount of water being encountered at all places, but due to easy access to the surface no unusual water problems are encountered. The water, however, has a decided acid reaction.

Gas.- On account of light cover and outcrop workings, no gas pressure has been encountered in any of these mines. At No. 1 mine an occasional feeder has been found where the gas could be detected in a safety lamp. These have been few and far between, however, and all the mines are termed nongassy.

Prospecting, Exploration, and Sampling.- Prior to being opened on a large scale, the properties had been well prospected by numerous wagon or small mines, but no diamond or churn drilling had been done. These small mines determined the quality and character of the coal before the present mines were opened. An average analysis of the coal bed worked at the various mines is as follows:

Moisture free	Ash	9.8
	Volatile matter	39.1
	Fixed carbon	51.1
		100.0
	Moisture	3.1
	Sulphur	4.0
	B.t.u.	13,290

Fusion point of ash, 2,250° F.

METHODS OF DEVELOPMENT AND MINING

Where the coal has outcropped on the hillsides the mines have been opened by drifts; the coal is delivered to the tipple by electric locomotives.

At No. 1 mine, a concrete-lined shaft 17 feet by 11 feet 9 inches inside diameter and 108 feet deep is used for hoisting. The shaft is equipped with a steel headframe and a Vulcan hoist, driven by a 150-hp. 2,200-volt a.c. motor, double cages, and automatic car-dumping devices. For a manway and for taking in material, a slope 300 feet long on a 30° pitch is used. A shaft 10 by 12 feet inside dimension and 115 feet deep, lined with 3-inch oak plank about 2,800 feet south of the hoisting shaft, is used as an air shaft.

Tipples.- The tipples and preparation plants are of wood and steel construction and are equipped with shaker screens, loading booms, and picking tables for sizing and cleaning the product for domestic purposes and for making steam.

Plan of Development and Mining.- The general plan of development has followed the room-and-pillar panel system, as shown by Figure 3. Two entries are driven in from the surface or shaft bottom on 40-foot centers, 8 feet wide and 7 feet high, leaving a barrier pillar of 150 feet on either side. Where these entries are on the butt cleats, pairs of

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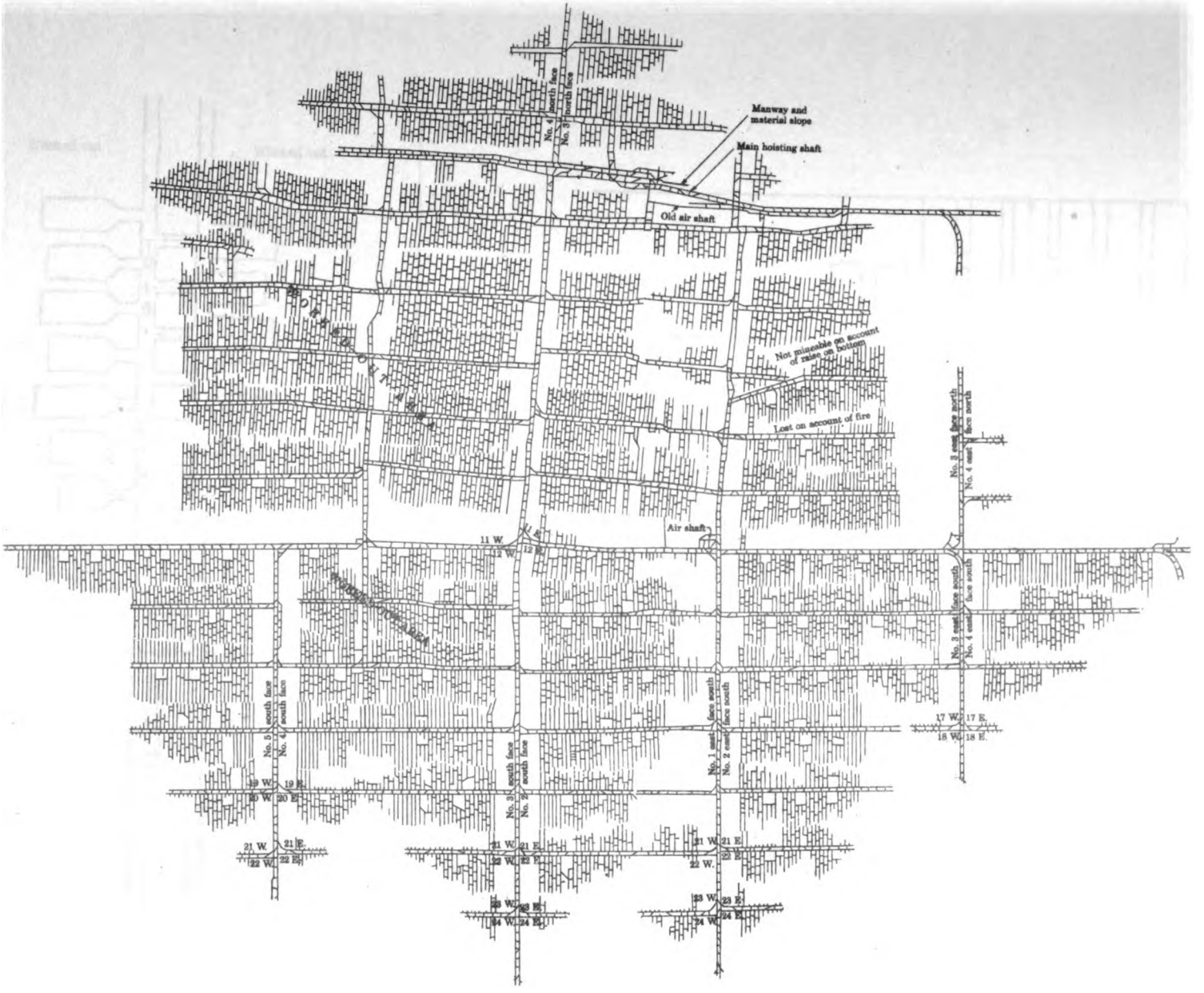

Figure 3.– Plan of mine development

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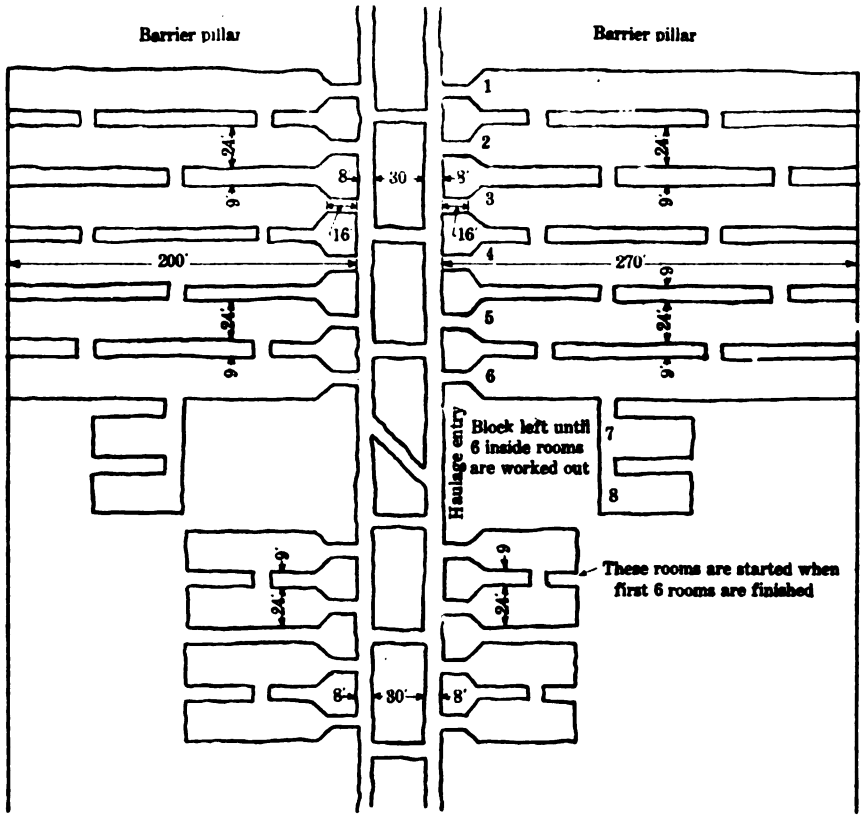

Figure 4. — Development method adopted at No. 3 mine to prevent riding over of a squeeze

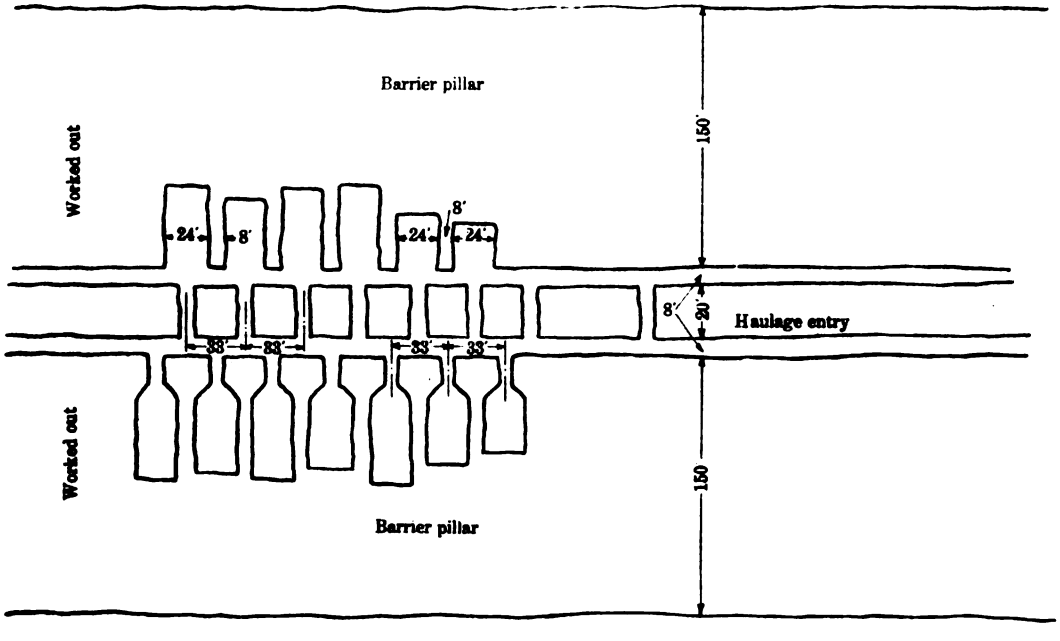

Figure 5. — Method of recovering part of the barrier pillar at No. 3 mine

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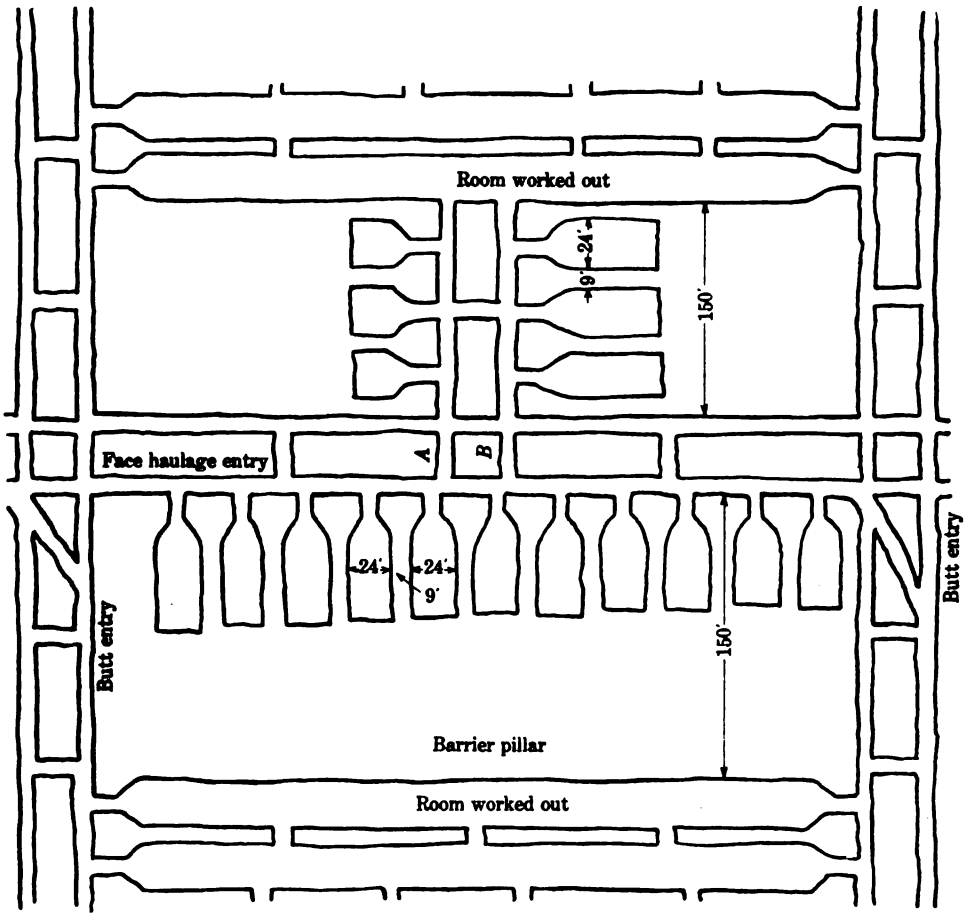

Figure 6. – Method used at No. 2 mine to recover part of the barrier pillars

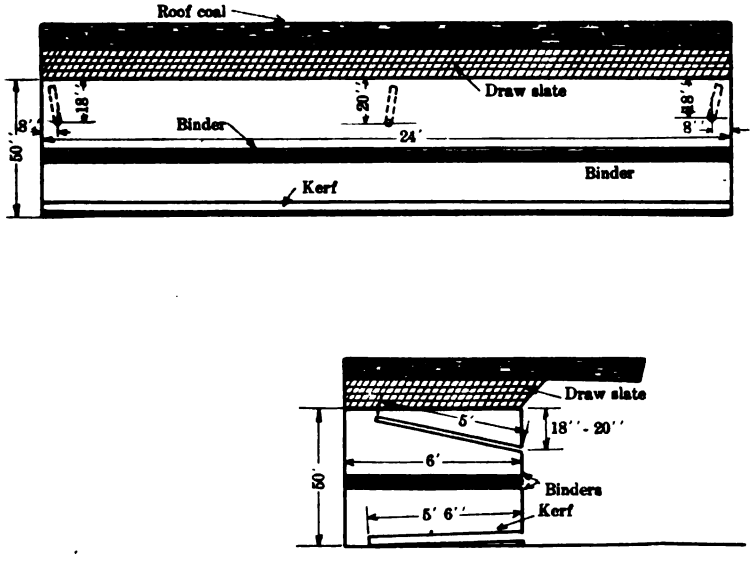

Figure 7. – Position of shot holes used in rooms 24 feet wide. The center hole is fired first

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face entries 30 feet apart are turned on 1,400-foot centers. From these face entries, butt or room headings are turned in pairs on 470-foot centers. Where the main headings are on the face slips, pairs of butt entries are turned on 470-foot centers.

From the butt entries, rooms 24 feet wide and on 33-foot centers are turned on one side as the entries advance and are driven until they connect with rooms from the next pair of butts, or until a cave or squeeze occurs, which is usually in 200 to 270 feet. Coal that is left because of a cave or squeeze is taken by the rooms on the next pair of butts. When the butt entries are holed-through about 1,400 feet to the adjoining face entries, rooms approximately 200 feet long are turned on the other side and connect with the rooms from the advancing side of the next pair of butts. At No. 3 mine no rooms are turned on the butt entries until the latter have holed-through to the next face entries, then six rooms are turned inby from each entry, leaving the space for the seventh and eighth rooms as a solid block of coal to prevent the riding over of a squeeze. Rooms are driven in this block when the first six are completed or are stopped because of a cave or squeeze and while the next six are being started. Since this method has been in use no rooms have been lost through the riding over of a squeeze. (See fig. 4.)

When the rooms are in about 100 feet they are gradually widened out to 26 or 27 feet, until at the ends of the rooms the pillars between the rooms are only 3 to 5 feet wide. Break-throughs for ventilation are driven through the room pillars at intervals of 40 to 80 feet. Room necks are made 8 feet wide and 18 feet long; the room is then widened out fanwise to 24 feet.

No attempt is made to recover room or butt entry pillars because of the treacherous immediate roof and the difficulty with which the limestone above the immediate roof is broken or controlled. A part of the coal left as barrier pillars to protect the main entries is recovered by two methods: (1) By turning rooms of the regular width and centers from both sides of one entry, as in Figure 5, and spacing them so that the room necks will not be opposite one another; or (2) by driving narrow places through to the worked-out or caved area, then turning rooms on the regular room centers. Figure 6 shows entries A and B turned from the face haulage entry and driven to the worked-out rooms on the butt entries. From each of these entries three rooms are turned on the face slips. From the face entries butt rooms are turned and driven to the worked-out room on the butt entries. All room centers are 33 feet apart.

Mining.- It is estimated that 55 per cent of the coal is extracted by the present system of mining. All the coal mined is undercut by electrically driven mining machines equipped with 6½-foot cutter bars, a majority of which are of the shortwall type. Some breast machines are used for entry driving where the miners cut their own coal; they are paid the regular breast-machine scale in addition to the loading rate. There are 31 shortwall and 14 breast machines at three of the mines; the fourth mine is not considered under this head because of its low tonnage and because the experiments with mechanical equipment at this time are not complete.

Table 1 shows the number of shortwall and breast machines at each mine and the average daily tonnage produced per machine at each mine in an average month:

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Table 1.- Work done by machines

Mine	Coal cut, tons	Days worked	Average daily tonnage	Machines working	Daily tonnage per machine
SHORTWALL MACHINES					
1	21,965	12	1,830	10	183
2	24,904	14	1,778	12	148
3	17,648	20	882	9	98
BREAST MACHINES					
1	2,695	12	224	4	56
2	5,188	14	370	8	46
3	883	20	44	2	22

Drilling and Blasting.- The shot holes for breaking down the coal are drilled by the miners, who use a breast auger for this purpose. The augers are about 1-3/4 inches in diameter, and the holes are drilled about 6 inches shorter than the mining. Three shot holes are used in rooms, as indicated in Figure 7, one on each rib and one in the center. All are placed about 20 inches from the roof and inclined so that the back of the hole will be 4 to 5 inches below the draw slate. The center hole is placed at about the center of the face, pointing slightly toward one rib. This hole is fired first, using a cartridge about 1-1/4 inches in diameter and 16 to 20 inches long filled with black blasting powder; where pellet powder is used, two sticks are put in this hole. After the coal from this shot has been loaded out, the rib shots are fired, using a cartridge 8 to 12 inches long and 1-1/4 inches in diameter. Where pellet powder is used, 1/2 to 1-1/2 sticks are employed, depending on the size of the burden.

In the entries only two shot holes are necessary, one on each rib and in the same relative position as the rib shots used in the rooms. The first shot is fired using a cartridge 16 to 24 inches long or with two sticks of pellet powder. When the coal from this shot has been loaded out, the rib shot is fired with a cartridge 8 to 12 inches long or with one-half to one stick of pellet powder.

All shot holes are tamped to the collar with moist coal slack and are fired with squibs by the miner. The cuttings are scraped from under the mining before any shots are fired.

During the period from Jan. 1, 1928, to March 31, 1929, 161,125 pounds of black blasting powder was used for breaking down the coal, and 738 pounds of dynamite for breaking down rock, a total of 161,863 pounds of explosive fired to produce 1,008,538 tons of coal, thus showing that 6.23 tons of coal was produced per pound of explosive used.

Table 2 shows the quantity of coal produced and the amount of explosive consumed at the various mines during this period:

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Table 2.- Explosives used and coal shot down

Mine	Coal produced, tons	Black powder used, pounds	Dynamite used, pounds	Coal per pound of black powder, tons	Coal per pound of dynamite used in rock, tons
1	276,275	30,750	163	8.98	1,695
= 2	424,900	78,000	125	5.45	3,399
3	281,721	46,200	450	6 10	626

Rooms.- Rooms are turned off the butt entries 8 feet wide for a distance of 3 cuts, or 18 feet, then widened out to 24 feet fanwise; the track is always in the center of the room. When the rooms have been driven in about 100 feet they are generally widened to 26 or 27 feet, and are driven this way until they are stopped by a local squeeze or a cave. As a rule the length of the room is 200 to 270 feet, depending on freedom from the above-mentioned causes.

Entries.- Entries 8 feet wide are advanced on the face or butt slips; rooms are always turned on the face slips. The entry and room turning work is performed by a crew of four men who cut, blast, and load the coal in these entries, often using a breast-type drill for drilling shot holes.

Extra compensation in the form of yardage as in Table 3 is paid for this narrow work, which also includes taking down and loading out the draw slate and any impurity that may have to be rejected.

Loading.- During the period under consideration, 1,008,504 tons of coal has been produced, all of which at No. 1, 2, and 3 mines has been hand-loaded on a contract basis. At No. 4 mine, experiments are being conducted with shaker conveyors in rooms and entry driving; one of these conveyors is equipped with a face-loading device and the other requires shoveling by hand. As this work is still in the experimental stage, complete data are not available; however, four men forming a crew will cut, blast, load, timber, and take care of the necessary deadwork in a shift of 8 hours, producing 40 tons of coal with the conveyor equipped with the face-loading device.

Table 3 gives the quantity of coal loaded during the period from Jan. 1, 1928, to March 31, 1929; a portion of the production at No. 4 mine was loaded mechanically.

Table 3.- Coal loaded at the four mines

Mine	Total tonnage	Loaders employed	Days worked	Average daily tonnage	Average tonnage per loader
1	276,275	288	171.5	1610.93	5.593
2	424,900	260	311	1366.24	5.255
3	281,721	168	354	795.82	4.737
4	25,644	15	127	201.92	13.461

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Deadwork.- The principal items under the head of deadwork that influence the mining of coal are (1) the extra compensation paid loaders and machinemen for narrow places; (2) the extra compensation paid for handling draw slate or stone, paid according to the schedule in Table 14; (3) the cleaning of falls back from the regular working faces by daymen; (4) the disposal of refuse on the surface.

The items of deadwork necessary for the miner to perform and included in the mining or loading rate are drilling, blasting, cleaning the coal of binders, slate, or other impurities, and handling the first 12 inches of draw slate, which is general practice. This also involves the care of the roof and its support in working places, and laying of track except curves and switches.

Timbering.- The immediate roof is the stratum of roof coal immediately above the draw slate when this is held it forms a fairly good roof in rooms, which are not of long life, but in entries it is difficult to hold without extensive support. This support is furnished in the shape of 6 to 10 inch I-beams, or by lengths of 60-pound T-rails placed on short blocks which rest on the coal, as in Figures 8 and 9. Tight lagging of 2-inch plank or split posts is used in most cases of entry roof support.

A definite system of roof support has been adopted for rooms, placed in the following manner: After the face has been cut, two posts, termed "road posts" are placed 30 inches from the face and 18 inches from the line of the rail; then, as the coal is loaded out, two posts called "gob posts" must be set on each side. As the face is advanced two more posts must be placed not more than 30 inches from the last road posts. Where the draw slate is not broken down with the coal, two or more posts are used for its support while the coal is being loaded out. (See figs. 10 and 11.) At Nos. 1, 2, and 4 mines five slate posts are used in each cut; at No. 3 mine seven slate posts are used. The location of the slate posts is left to the discretion of the miner or foreman.

Good-quality posts not less than 5 inches and frequently 8 inches in diameter are used. Cap pieces 2 inches thick, 6 inches wide, and 12 inches long are used on all posts. In the rooms the cap pieces are placed at right angles to the track on road posts and parallel with the track on gob posts.

During 1928 the following timber for posts and I-beams or 60-pound rail for crossbars were used for roof support (Table 4):

Table 4.- Posts and crossbars used during 1928

Mine	Coal produced in 1928, tons	Posts used	Tons per post	Total linear feet, posts	Tons per linear foot of posts	Crossbars entry supports. I-beams and rail	Tons per crossbar	Cap pieces	Tons per cap piece
1	189,858	47,480	3.99	284,880	.6664	343	553.52	39,397	4.82
2	326,615	88,299	3.69	461,229	.7082	100	3,266.15	(1)	(1)
3	224,396	54,660	4.11	328,137	.6838	2,979	75.66	56,966	3.93
4	14,432	2,372	6.09	14,232	1.0100	(1)	(1)	3,500	4.12

1 - No record obtained.

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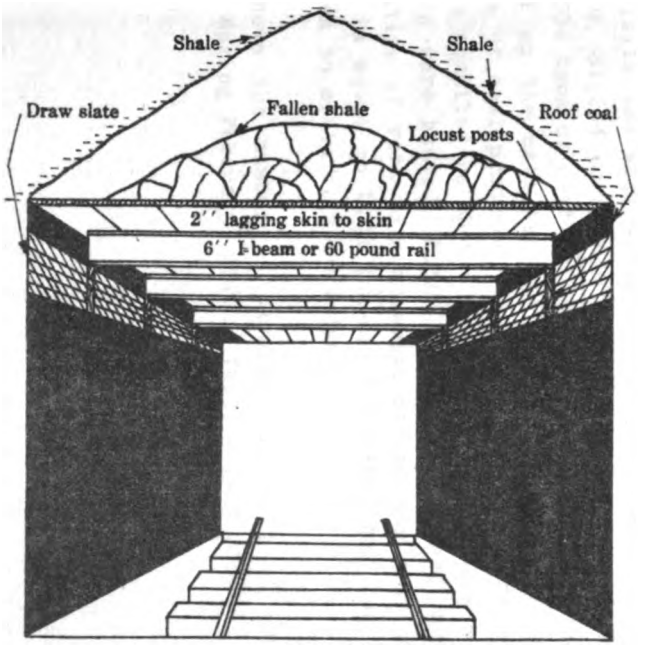
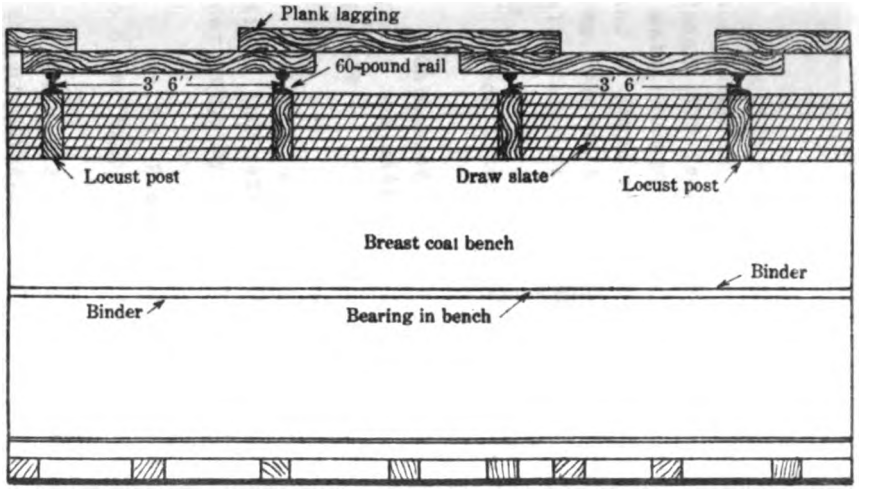


Figure 8. – Method of supporting the entry roof



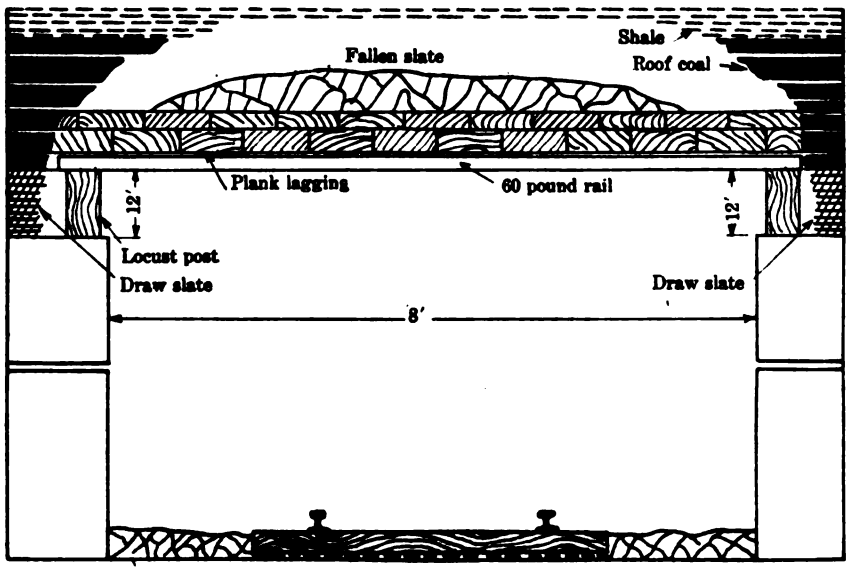


Figure 9. – Method of lagging and of supporting the entry roof

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Haulage.- The mine tracks, size of trip, and equipment have been standardized. The track gauge is 42 inches. The standard radii of curves and turnouts are 140 feet for No. 5 frogs, 185 feet for No. 6 frogs, 90 feet for No. 4 frogs, and 60 feet for No. 3 frogs on the main haulage, and on room turnouts curves of 16-foot radius with a No. 1-1/2 frog. Sixty and 40 pound rails are used on the main haulageways and 20-pound rails on butt entries and rooms, placed on 5 by 6 inch by 6-foot ties spaced on 24-inch centers. The tracks are kept well graded and in line.

Room tracks are placed by the miners and all turns and switches by daymen.

Gathering locomotives or drivers deliver the empty cars to the room neck, from which point the miner pushes them to the face; payment for this is included in the regular loading rate.

At No. 1 mine the loaded cars are gathered from the rooms by 6-ton gathering locomotives and delivered to the passbys, from where they are hauled to the shaft bottom in 58-car trips by 13-ton locomotives.

At No. 2 mine mules are used to gather the cars from the rooms; cars are hauled in 4 to 6 car trips to the passbys, and from there are hauled to the tipple in 40-car trips.

At No. 3 mine the cars are gathered from the rooms by mules hauling 4 to 6 car trips and by gathering locomotives hauling 6-car trips to the passbys, from where the cars are hauled to the tipple by 13-ton locomotives in 40-car trips.

At No. 4 mine the cars are hauled from the conveyor loading points to the surface by a 10-ton locomotive. The haulage at this mine has not been given detailed consideration in this paper because, as already stated, it is in a development and experimental stage.

Table 5 details the work accomplished on the main haulage at the several mines. During February, 1929, 37,534 cars were hauled. Of these, 33,157 carried coal and 4,377 slate or refuse; 74,004 tons of coal was produced and 180,722 ton-miles of work accomplished in hauling this coal on the main haulage at the three mines; this is equal to 2.44 ton-miles of work per ton of coal produced, without considering the 4,377 cars of slate hauled. Table 6 also has been compiled to show the work accomplished on a typical day during April, 1929, when 2,466 cars were hauled, 2,245 of which were coal and 221 slate or other mine refuse; 12,374 ton-miles of work were accomplished on the main haulage in producing 4,725 tons of coal. This is equal to 2.62 ton-miles of work per ton of coal produced, no consideration being given to slate or mine refuse.

Table 7 shows the number of cars and quantity of coal gathered per mule and gathering locomotive during February, 1929. Table 8 is a typical day in April, 1929.

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Table 5.- Details of main haulage at three mines during February, 1929

Item	Mine 1	Mine 2	Mine 3
Time worked, days	12	14	20
Locomotives working	2	2	2
Cars hauled	11,127	13,062	13,345
Cars of slate	1,060	1,991	1,326
Cars of coal	10,067	11,071	12,019
Total, tons	24,326	30,386	19,292
Average, tons per day	2,025	2,168	965
Average per locomotive, tons per day	1,013	1,084	482
Average weight of coal in car, tons	2.416	2.517	1.605
Weight of empty car, tons	1.2	1.2	0.8
Average haul, miles	1.25	1.4	1.1
Work in hauling coal, ton-miles	28,407	42,540	21,221
Work in hauling car, ton-miles	30,201	37,199	?1,153
Total work, ton-miles	58,608	79,739	42,374
Work per ton of coal produced, ton-miles	? 41	2 62	2 196

Table 6.- Work done on a typical day in three mines

Item	Mine 1	Mine 2	Mine 3
Locomotives working	1	2	2
Cars hauled	1,028	889	549
Cars of slate	89	86	46
Coal hauled	939	803	503
Coal produced, tons	2,021	1,910	794
Coal per locomotive, tons	2,021	955	397
Average weight of coal per car, tons	2.152	2.378	1.58
Weight of empty car, tons	1.2	1.?	0.8
Average haul, miles	1.25	1.4	1.1
Work in hauling coal, ton-miles	2,526	2,674	873
Work in hauling car, ton-miles	2,817	2 698	885
Total work, ton-miles	5 343	5,372	1,758
Work per ton of coal produced, ton-miles	2.644	2.812	2 215

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Table 7.- Gathering haulage in three mines during February, 1929

Item	Mine 1	2	3
Days worked	12	14	20
Locomotives worked	8	-	3
Mules worked	-	20	9
Cars gathered	11,127	13,062	13,345
Cars of slate	1,060	1,991	1,326
Cars of coal	10,067	12,071	12,019
Total quantity, tons	24,326	30,386	19,292
Cars gathered by locomotives daily	927	-	255
Cars gathered by mules, daily	-	933	412
Average daily tonnage	2,025	2,170	965
Average per locomotive, ton per day	253	-	113
Average per mule, tons per day	-	109	66
Cars gathered per locomotive, daily	116	-	85
Cars gathered per mule, daily	-	47	46

Table 8.- Gathering haulage on a typical day

Item	Mine 1	2	3
Locomotives worked	8	-	3
Mules worked	-	20	9
Cars gathered	1,028	889	549
Cars of slate	89	86	46
Cars of coal	939	803	503
Coal produced, tons	2,021	1,910	794
Cars gathered by locomotives	1,028	-	138
Cars gathered by mules	-	889	411
Average coal per car, tons	2.153	2.378	1.58
Coal per locomotive, tons	253	-	66
Coal per mule, tons	-	96	66
Cars per locomotive	128	-	46
Cars per mule	-	44	46

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At No. 1 mine, during February, eight gathering locomotives were used to gather 11,127 cars; 1,060 of these were slate or mine refuse cars and 10,067 were coal cars, containing 24,326 tons of coal which was hauled in 12 working days. The daily average coal tonnage per gathering locomotive, therefore, was 253 and the average number of cars per locomotive was 116, including cars loaded with slate.

At No. 2 mine in 14 working days 13,062 cars were gathered, 1,991 of which were slate and 12,071 coal, containing 30,386 tons. Twenty mules were used on the gathering haulage and gathered daily an average of 108.5 tons of coal, or 46.65 cars, including slate.

At No. 3 mine in 20 working days 13,345 cars were gathered, 1,326 of which were slate and 12,019 coal, containing 19,292 tons. Three gathering locomotives were operated and each gathered daily an average of 112.6 tons of coal or 85.15 cars, including slate. Nine mules were also used on the gathering-haulage system, and each gathered daily an average of 66.3 tons of coal or an average of 45.75 cars, including slate. On a typical day during April, at No. 1 mine eight gathering locomotives were used. They gathered 1,028 cars, 939 of which were coal and 89 slate.

At No. 2 mine 20 mules gathered 889 cars, 803 of which were coal and 86 slate; each mule, therefore, gathered 95.5 tons of coal, or 44.45 cars, including slate.

At No. 3 mine 549 cars, 503 of which were coal and 46 slate, were gathered. Three gathering locomotives were operated and each gathered an average of 66.36 tons of coal, or 46 cars, including slate; nine mules were also used and each gathered an average of 66.18 tons of coal or an average of 45.75 cars, including slate. On this typical day, 4,725 tons of coal was produced in the three mines, 2,220 tons of which was gathered by 11 gathering locomotives; the average, therefore, was 201.81 tons per locomotive; 2,505 tons were gathered by 29 mules, an average of 86.38 tons of coal per mule; 221 cars of slate were also gathered and hauled on this typical day.

Mine Cars.- Wooden mine cars are used, equipped with end gates, 18-inch wheels in solid bearings, and ratchet brakes. Table 9 gives the number of cars at each operation, number of times loaded with coal and slate, and average capacity of coal for February, 1929.

Table 9.- Details of car operation

Mine	Cars	Average load of coal, tons	Total cars loaded	Total cars coal	Total cars slate	Days the mine worked	Average cars loaded daily	Average number of times each car was loaded daily
1	425	2.416	11,127	10,060	1,060	12	926	2.175
2	342	2.517	13,062	11,071	1,991	14	933	2.722
3	400	1.605	13,345	12,019	1,326	20	667	1.668

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Drainage and Pumps.- Mines Nos. 1, 2, and 4 may be termed damp, as a little water is encountered throughout. The water is taken care of by pumps and drainage ditches. No. 3 mine is decidedly wet at all points due to the light cover which rarely exceeds 70 feet and the close proximity of a number of strip workings. The drainage at this mine is a difficult problem during the wet season and tends to increase the haulage problems. The mine water has a decided acid reaction.

Table 10 gives a list of the pumps with their capacity and motive power, at each mine:

Table 10.- Details of pump equipment

Mine	Triplex pumps	Gallons per minute	Motor hp.	Centrifugal pumps	Gallons per minute	Motor hp.	Piston pumps	Gallons per minute	Motor hp. minute	Total gallons per minute	Total power
					250						
1	1	(220)	20	2	300	40	-	-	-	770	100
2	1	(326)	20	1	600	15	-	-	-	926	35
	(1	90	7½)								
3	(2	150	10)	-	-	-	-	-	-	490	37½
	(2	50	5)								
							3	50	3)		
4	-	-	-	-	-	-	1	90	5)	240	14

Ventilation.- The ventilation is supplied at the various mines by electrically driven fans. Table 11 lists the fans used, quantity of air delivered per minute, water gauge in inches, capacity of motor, and whether exhaust or blowing.

There is a fairly good supply of air at the working faces. Stoppings are constructed of hollow tile laid in cement mortar, and of wood, for which 1 by 8 inch shiplap is supplied. Doors are constructed of 1 by 12 inch lumber doubled and hung to close with the air current.

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Table 11.- Details of ventilating equipment

Item	Mine 1	2	3	4
Size of fan	7 ft. by 42 in.	5 ft. by 38 in.	5 ft. by 28 in.	6 by 4 ft.
		5 ft. by 36 in.	4 ft. by 30 in.	6 by 4 ft.
Type of fan	Blower	Blower	Blower	exhaust
		Blower	Blower	Blower
Water gauge, inches	3	1	3.4	1.5
		1.25	1.5	1.5
Air, cubic feet per minute	125,000	40,000	70,000	50,000
		75,000	20,000	25,000
Total		115,000	90,000	75,000
Motor, horsepower	100	40	40	50
		50	10	15
Total		90	50	65
Voltage	2,200 a.c.	250 d.c.	2,200 a.c.	220 a.c.
		440 a.c.	230 d.c.	220 a.c.

Power, Kind and Voltage.- Purchased power is furnished to the several mines at 4,000 and 2,200 volts a.c. units where it is converted into 250 volts d.c. or 440 and 220 a.c.; 250 volts d.c. is the standard on all underground equipment. The following units are used at the several mines for converting high tension to low voltages (Table 12):

Table 12.- Converter equipment

Mine	Motor generator sets	Power, kw.	Rotary converters	Power, kw.	Total power, kw.
			(	200)	
1	-	-	2 (	250)	450
	(	150)			
2	2 (	200)	-	-	350
3	2	200	-	-	400
4	-	-	2	200	400

Table 13 gives the kilowatt-hours of power used at the various mines, tons of coal produced, and kilowatt-hours per ton of coal:

Table 13.- Power consumption

Mine	Kilowatt-hours consumed	Tons of coal produced	Kilowatt-hours per ton produced
1	1,496,500	372,352	4.019
2	1,360,800	446,780	3.068
3	1,194,000	241,622	4.941
4	50,160	14,380	3.488

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WAGES, CONTRACT AND BONUS SYSTEMS

Table 14 gives the scale of wages by which all employees are being paid. The miners are paid on a per-ton basis plus a yardage rate for all narrow work and draw slate over a certain thickness; they also furnish the explosive for blasting coal and slate and purchase it from the company. Cutters are paid on a tonnage basis, plus a yardage rate for narrow work. Daymen are paid at a daily rate, eight hours constituting a day's work. Supervising officials are paid on a monthly basis. As a rule, entries and room necks are driven by a crew of two to three men who cut, blast, and load the coal, performing all the labor necessary for driving the entries, break-throughs, and room necks. The company furnishes the mining machine and pays the regular scale of wages as called for under the several items. Many entries are driven on double shift, the miners being required to load out a full cut each shift.

No bonus in addition to the regular wage scale is being paid at these properties; a plentiful supply of good labor is available.

Some experimental work is being done with shaker conveyors at one mine where all the men forming the crew are paid on a daily rate basis.

Table 14.- Wages paid to all employees

Inside day labor wage-scale, per day	
Motorman	$5.00
Drivers	5.00
Bottom cagers	5.00
Track layers	5.00
Timbermen	5.00
Snapper on crab gathering locomotives	5.00
Trip riders on haulage locomotives	4.75
Water haulers	4.75
Machine haulers	4.75
Track layers helpers	4.75
Timbermen helpers	4.75
Bratticemen	4.75
Trappers	3.00
Couplers and greasers	3.00
All other inside day labor	4.50
Machine cutting by the day	5.00
Outside day-labor wage scale, per day	
First blacksmith	5.25
Second blacksmith	5.00

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Blacksmith helpers	4.75
Mine carpenters	4.75
Checkers (drm runners)	4.75
Dumpers	4.50
Trimmers on railroad cars (lump only)	4.30
Slate-pickers (on tables or cars)	4.00
Couplers and greasers	2.75
All other outside day labor (except boys)	4.00

Pick mining scale

Run of mine coal, per ton	0.85
Babk measure, per foot, room 24 feet wide, coal 5 feet, per foot	4.13
Bank measure, entries not to exceed 6 feet wide, per yard	5.19
Bank measure, entries not to exceed 7 feet wide, per yard	5.70
Bank measure, entries not to exceed 8 feet wide, per yard	6.21

Room-turning entry price

(That for every 3 inches above or below the regular heights of 5 feet of coal on a bank measure system in both entries and rooms there shall be paid a proportionate advance or decline in the mining rate.)

Entry dry stone taken down and loaded, per yard	2.00
Entry dry stone up, per yard	1.62
Break-throughs between entries, stone coming down, handled or loaded, per yard	2.08
Break-throughs between entries, stone up, per yard	1.62
Break-throughs between rooms, stone up, per yard	1.58
Taking down and gobbing stone in break-throughs	.38
Room turning, 7 feet wide, 21 feet deep	8.22
Room turning, 10 feet wide, and under 12 feet wide and 15 feet deep	5.65
Room turning, 12 feet wide to 15 feet wide, and 15 feet deep	2.25
Room turning over 15 feet wide, tonnage only	-

Machine mining scale, chain machines

Cutting in rooms (any type breast machine) per ton	.11
Cutting in rooms (any type short-wall machine) per ton	.09
Cutting in rooms (any type arc-wall machine) per ton	.05
Cutting in entries, break-throughs between entries, break-throughs between rooms, and turning rooms, 8 feet wide, per ton	As above
and extra per yard	.2415

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Cutting in entries, break-throughs between entries, break-throughs between rooms, and turning rooms, 10 feet wide, per ton	As above
and extra per yard	.2113
Cutting in entries, break-throughs between entries, break-throughs between rooms, and turning rooms, 12 feet wide, per ton	As above
and extra per yard	.1811
Hand drilling, shooting, and loading, in rooms, per ton	.58
Hand drilling, shooting, and loading, in entries, break-throughs between entries, break-throughs between rooms, and turning rooms, 8 feet wide, per ton	.58
and extra per yard	.75
Hand drilling, shooting and loading, in entries, break-throughs between entries, break-throughs between rooms, and turning rooms, 10 feet wide, per ton	.58
and extra per yard	.665
Hand drilling, shooting, and loading, in entries, break-throughs between entries, break-throughs between rooms, and turning rooms, 12 feet wide, per ton	.58
and extra per yard	.58

SUMMARY OF COSTS

Tons Mined During Period.- During November, 1928, which has been used as a typical month for the purpose of arriving at the following cost percentages, 104,497 tons of coal was mined at the four operations (Table 15):

Table 15.- Mining costs per ton expressed in percentages

	Labor	Material	Total
Mining	50.00	2.11	52.11
Deadwork	5.07	0.28	5.35
Timbering	2.47	3.12	5.59
Ventilation	1.70	0.31	2.01
Transportation	11.00	5.43	16.43
Tipple	5.29	-	5.29
Power	0.59	5.11	5.70
Pumping	1.23	0.46	1.69
General mine expense	4.86	0.97	5.83
Total	82.21	17.79	100.00

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Mining, Labor, and Material.- Mining, labor, and material include the cost of cutting, blasting, maintenance, and supplies for mining machines.

Deadwork and Material.- Labor and material cost of yardage are paid as compensation for narrow work in entries, air courses, and break-throughs, and for draw slate or roof over a certain thickness, cleaning of falls, and disposal of slate or refuse on the surface.

Timbering and Material.- Labor performed by daymen, cost of material for roof support on entries and air courses, and posts and cap pieces for roof support in rooms are chargeable to timbering.

Ventilation and Material.- Ventilation and material costs include labor and material, cost of operation and maintenance of ventilating equipment, construction of brattices, stoppings, and doors.

Transportation and Material.- Transportation and material costs include labor and material, cost of main and gathering haulage, maintenance of and repairs to locomotives, mine tracks, car repairing, shaft bottom, and maintenance of mules used for haulage.

Tipple.- Tipple costs include the cost of operation and maintenance of tipples and preparation plants.

Power and Material.- Power and material costs include labor and material, cost of operation and maintenance of power lines, substations, and purchase of power.

Pumping and Material.- Labor and material, cost of operation and maintenance of pumps and drainage ditches are included in pumping and material costs.

General Mine Expense and Material.- Costs of labor and material, supervision, clerical force, and general outside maintenance are included under general mine expense and material.

UNITS OF LABOR

Table 16 gives the total tonnage produced at each mine for the first three months of 1929, the number of days worked, average number of men employed daily, average daily tonnage at each mine, the number of tons per man employed daily, total man hours worked, and tons produced per man hour unit.

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Table 16.- Units of labor

Item	Mine 1	2	3	4
Coal produced, tons	86,417	98,285	57,325	14,212
Days worked	43.5	46.5	60	53
Average production, tons per day	1,987	2,114	955	268
Men employed:				
Loaders	288	260	169	15
Machinemen	42	22	18	4
Daymen	70	70	64	6
Outside men	37	30	28	4
TOTAL	437	382	279	29
Coal per man, tons:				
Loader	6.9	8.1	5.7	17.8
Dayman	28.4	30.2	14.9	44.7
Outside man	53 7	70 5	34.1	67
Average	4.6	5.5	3.4	9.2
Man hours for inside men	139,200	130,944	120,480	10,600
Coal per man hour inside, tons	0.6208	0.7506	0.4758	1.3407

SUMMARY AND REVIEW OF PRACTICE

Mining Method.- The room-and-pillar panel method of mining as used at these mines is the general practice in eastern Ohio mines. Because of the treacherous nature of the immediate roof and the expected difficulty of controlling and breaking the bed of limestone about 14 feet thick which lies 3 to 9 feet above the coal bed, no attempt is made to recover pillars. To delay a squeeze or cave while the rooms are being driven their required distance of 270 feet on the advance side is the greatest problem in the mining method. This is readily apparent when groups of six to ten rooms are started and driven abreast and gradually widened leaving a room pillar which gradually narrows in size until often it is only 3 to 5 feet wide before the rooms reach their projected distance.

Cutting.- The average daily tonnage cut by 31 shortwall machines during an average month was 112.64 tons each. At No. 1 mine an average of 183 tons each for 10 machines was made, while at No. 3 mine the average was 98.04 tons each for 9 machines during this same period.

Breast machines are used for entry driving and room turning. A crew of four to six men perform all the work pertaining to putting the coal into the mine car. Fourteen of these machines were used during an average month, and each of the 14 machines cut an average of 45.67 tons daily.

Drilling and Blasting.- Drilling and blasting are part of the miner's duties and are paid for in the loading price. The shot holes are drilled with hand augers in Nos. 1, 2, and 3 mines, while at No. 4 mine an electric drill is used in connection with the machines.

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Loader.- The quantity of coal produced per pound of explosive varies from 8.98 at No. 1 mine to 4.15 at No. 4 mine, with an average of 5.23 pounds for the four mines during a 15-month period. Some experiments are being conducted at this mine, with pellet powder in place of black blasting powder, the object being to increase the percentage of the larger coal.

Loading.- The experiments being conducted with mechanical loaders at No. 4 mine are not advanced to the point where definite data can be obtained. Therefore hand-loading is the practice, and two men working together have two working places; while one place is being prepared, they load coal at the other.

The first three months of 1929 may be termed a regular operating period. During this time the daily average quantity per loader at the four mines was 7.27 tons; at the mines where hand-loading is the practice it varied from 8.1 tons at No. 2 mine to 5.7 tons at No. 3. At No. 4 mine where mechanical loaders are working it was 17.8 tons per loader.

Timbering.- Table 4 shows that a total of 1,088,478 linear feet of timber was used to produce 755,301 tons of coal during 1928, thus indicating that 0.6939 ton of coal was produced per linear foot of timber used for roof support in rooms. During the same period 3,422 I-beams or rails were used for crossbars on entries and haulageways.

The method of support for rooms and draw slate is adequate for the requirements of the roof. No posts are recovered from rooms when they are worked out.

The method adopted of using I-beams or rails for crossbars on entries and haulageways with tight lagging gives satisfactory protection against pieces of slate which may slough off and strike any person who may be passing.

The practice of hitching legs, supporting crossbars, into the rib is commendable, as thereby any chance of a leg's being knocked out by derailed cars or locomotives is iliminated.

Ventilation.- The ventilation at these mines does not present any unusual problems because of the easy access to surface openings.

Transportation.- The haulage or transportation of the coal from the face to the tipple involves no unusual problems and is average for a flat coal bed. The average for five main-haulage locomotives at three mines was 1,031.7 tons per day, while 11 gathering locomotives averaged 227.7 tons, and 29 mules gathered an average of 76.5 tons daily.

At these same mines 1,167 mine cars are used which turn around an average of 2.16 times daily. The tracks are kept well graded, clean, and on line.

General Underground.- The general underground conditions of the mines are as good as may be expected where the coal bed has a treacherous immediate roof. The protection from falling slate on entries and haulageways by the method practiced is exceptionally good. No

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rock-dust has been used, neither has permissible explosives been adopted for blasting. Open flame lights are used by all employees.

During the first three months of 1929, 5.17 tons of coal was produced daily per man employed underground and 0.6384 ton per man hour worked; 4.76 kilowatt-hours of power was used for each ton of coal produced.

Table 17 is a summary of all the operations at the four mines:

Table 17.- Summary of operations at the four mines

Cutting machines, 31 shortwall, tons per average shift	112.64
Cutting machines, 14 breast, tons per average shift	45.67
Coal produced per pound of explosive, tons	6.23
Coal produced per linear foot of timber used, tons	0.6939
Coal produced per post used, tons	3.92
I-beams or rails used for crossbar entry support	34.22
Average daily quantity per main-haulage locomotive in three mines, tons	1031.7
Work performed daily on main haulage in three mines, ton-miles	12,373.96
Work on main haulage per ton of coal produced, ton-miles	2.6188
Coal gathered by gathering locomotives, per cent	53
Coal gathered by mules, per cent	47
Average daily quantity per gathering locomotive, tons	227.7
Average daily quantity per mule, tons	76.5
Average number of cars gathered by locomotives daily	106
Average number of cars gathered by mules daily	44.8
Average number of times each car is loaded per shift	2.16
Total power consumed in 1928, kilowatt-hours	3,579,600
Power consumed per ton of coal produced, kilowatt-hours	4.76
Coal per man employed underground, tons	5.17
Coal per man hour, tons	0.6384
Average daily tonnage per loader (four mines)	7.27
Average daily tonnage per day man (four mines)	25.25

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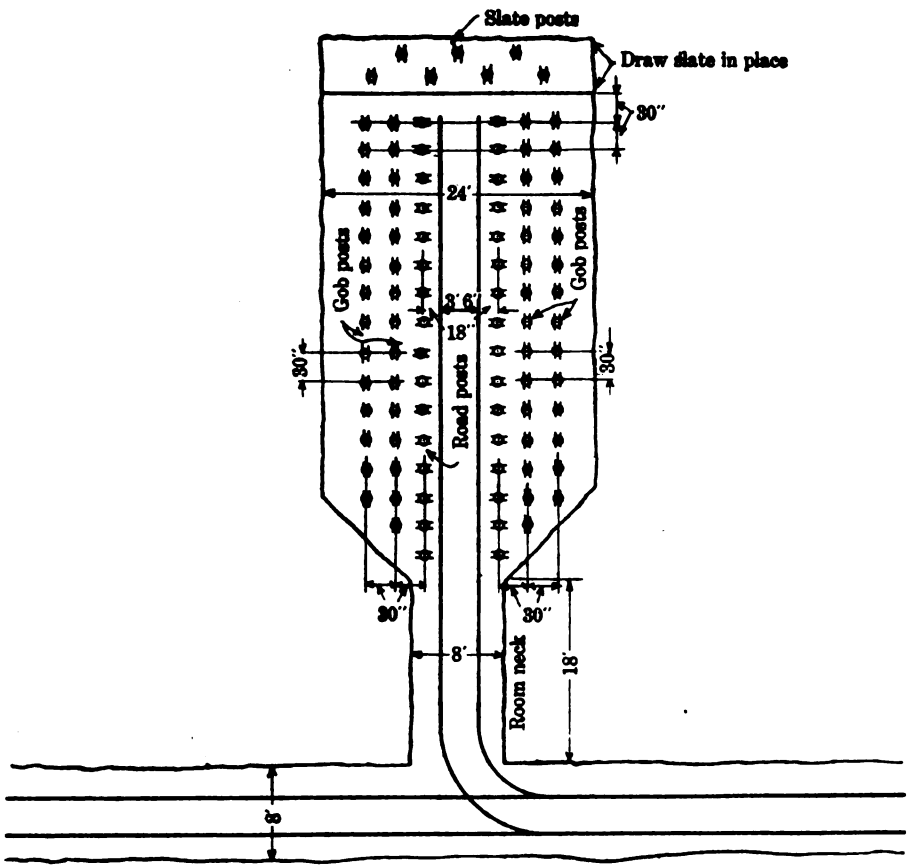

Figure 10. — Position of room posts and safety or slate posts in rooms 24 feet wide

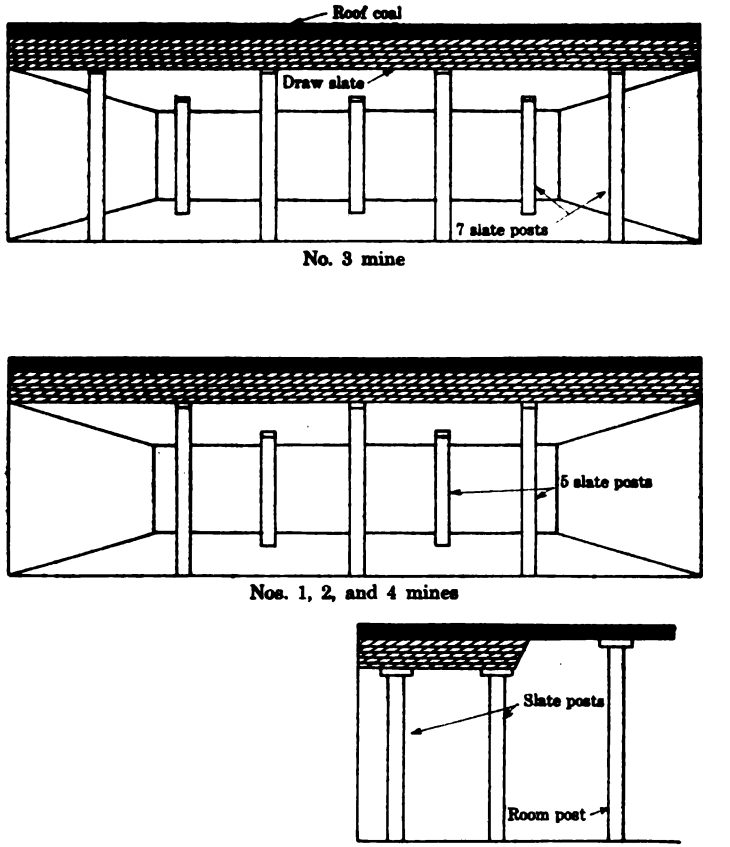

Figure 11. — Methods of posting draw slate while coal is being loaded

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